UNITED STATES DEPARTMENT OF AGRICULTURE
Agricultural Research Service

ARS 42-93
June 1964

DISPOSAL OF POULTRY MANURE AND OTHER WASTE

By Harry J. Eby,[1]

THE PROBLEM

With the confinement housing of poultry, both broilers and layers, there has come an increasing problem of manure and other waste disposal.

The manure disposal problem is aggravated by several factors:

- Broiler and layer enterprises are being surrounded by urban growth. Urban dwellers are not usually tolerant of farm-produced odors.
- With the encroachment of the urban development, there is a corresponding decrease in land areas available upon which to spread the accumulated manures.
- Where land is available, the weather may not be such that manure can be spread when available, i.e., fields may be muddy, snow covered, or in such a stage of growth as precludes the spreading of a manure that is apt to burn young plants or ruin maturing crops.

Thus, the disposal of tens of thousands of tons of poultry manure per year does present a problem.

It has been estimated that there is about a 3 percent loss of birds in a broiler operation, broken down roughly as follows: 2 percent during the first 1 to 3 weeks of life of the bird and 1 percent during the "growing out" period. Disposal of these birds involves two problems: (1) disposal of the birds physically and (2) disease control.

This publication is presented to describe the various methods of disposal. No attempt is made to be specific with any one method. A list of references is included that covers most of these methods thoroughly.

Each operator or farmer will have to decide for himself which method is best for him as no two operations present exactly the same problems.

---

[1]Agricultural Engineer, Agricultural Engineering Research Division, Agricultural Research Service, U.S. Department of Agriculture.

SOME POSSIBLE SOLUTIONS FOR MANURE DISPOSAL

Many solutions have been advanced for the disposal of poultry manures. A review of these follows.

Spreading on Fields (Dry)

This method would be excellent generally, except that poultry manure is not collected daily and there is a considerable bacterial breakdown in the material; this liberates nitrogen in the form of ammonia, which reduces its primary fertilizing value. This is unavoidable where poultry houses are cleaned out at specified intervals--as broilers are shipped to market or at monthly or greater intervals for layers.

Even if the intent were to spread the manure daily, weather conditions would prevent this and storage facilities would be required. Storage facilities can be expensive if the stored material is to retain its nutrients. There is also the problem of getting the material into and out of storage.

Spreading on Fields (Wet)

If this method of disposal is used, the manure has to be in a liquid or semiliquid state. Liquid handling requires a watertight storage tank or pit.

One method for the disposal of liquid manure is either pumping the material into a spreader tank (truck- or trailer-mounted) or pulling it into it by vacuum. Some spreader tanks are equipped with vacuum pumps that exhaust the air from the tank. This vacuum system is limited to a lift of not more than 25 feet and has the additional disadvantage that once the vacuum is broken the material may flow back into the pit or, if caught at once and none is lost, a considerable amount of time is required to build the vacuum back up again.

This method of disposal is also subject to the drawbacks previously listed (p. 1). It has an advantage in that the material may be stored for prolonged periods or at least until it is convenient to spread.

A second method for the disposal of liquid manure is by sprinkler irrigation. The advantages of this system are that the material may be spread regardless of the weather as long as a man can get into the fields and move the pipeline and, once pumping has started, the farmer can do other chores. The disadvantages are that an additional outlay of capital is required, and, as in both previous disposal systems, land areas are required upon which to spread the manure.

A third variation of wet disposal, which probably would be applicable only in the Western States, is via irrigation ditches. In the areas where this is practiced, seasonal factors are probably of no significance. Nor is there likely to be any danger of burning young growth, because the manure is diluted and partially decomposed prior to application to the fields. Such odors as would be present would probably be of no concern because of distances between residences.

As with the sprinkler disposal method, once the pump is started the farmer can devote his time to other chores. The additional capital requirements over and above the cost of the holding pit would be the purchase of a pump and sufficient pipe to reach the irrigation ditch or ditches.

Ground or Pelleted Home Garden Fertilizers

Another method of poultry manure disposal is by dehydrating and sale of the dehydrated material to home gardeners. Several drawbacks to this means of disposal, particularly in pelleting, are:

- Dehydrating equipment is expensive.
- In order to justify the investment and to pay for overhead, the dehydrating equipment should be run at near capacity the year around; this means that a steady and large volume of manure must be constantly available for processing.
- Storage must be provided to protect the dehydrated product.
- A distribution system must be organized. Either retail outlets must be lined up or a middleman used for distributing to retailers; thereby, the profit margin is cut.
- Owing to the rapid loss of nutrients, particularly nitrogen, in unprocessed stored poultry manure, each batch of manure going through the dehydrator must be analyzed and nutrients added to give a uniform product. Many States require a statement as to quantity of plant nutrients contained in the fertilizer.
- Finally and perhaps the most discouraging aspect of manure disposal by this method is the lack of popular acceptance by the public. This may be because of odors produced when this material becomes wet.

Lagooning

Lagooning of poultry manure has received considerable publicity in the popular press. Unfortunately, lagoons and the manner in which they function are not thoroughly understood by those who construct them and by those who are responsible for the safeguarding of public health because information is generally lacking.

In congested areas, where conflicts are most likely to occur, the builder of a lagoon will want to install as small a lagoon as possible for economic reasons. On the other hand, those responsible for the maintenance of public health will want maximum safeguards. Therefore, with no generally acceptable guidelines to go by, differences of opinion will exist and relations will be strained.

Indoor Lagoons

Indoor lagoons should be located under the feeders and waterers in order to collect as much of the waste material as possible with a minimum of labor. In order to stabilize the material dropping into the lagoon, a capacity of $1\frac{1}{2}$ cu. ft. of water per bird is desirable.[2]

This type of lagoon is not aerobic (oxygen consuming). Therefore, the products of decomposition are different from those of an aerobic lagoon. However, those decomposition products that are odor producing are generally water soluble in the amounts produced and in the volume of water given above. Principal gases produced are methane, practically odorless; ammonia, odorous but soluble; hydrogen sulfide, odorous but soluble; carbon dioxide, odorless; carbon monoxide, trace, odorless; nitrogen, trace, odorless.

---

[2] Manual of Practices #8. Federation of Sewage and Industrial Wastes Associations. 4435 Wisconsin Avenue, N.W., Washington, D.C.

One disadvantage of the indoor lagoon is the accumulation of floating material--feathers and litter--and the formation of film--caused by hydrocarbons--on the surface of the lagoon. These are no great problem under anaerobic conditions. The problem arises when the indoor lagoon is emptied into an outdoor aerobic (oxygen-consuming) lagoon. At this time any floating material or film interferes with the surface absorption of oxygen and screens light entering the lagoon so that the photosynthesis process carried on by the algae is reduced.

Where indoor lagoons are used in poultry houses of more than one floor, consideration must be given to the additional weight that must be supported.

Outdoor Lagoons

Outdoor lagoons can be divided into three categories:

1. Anaerobic.--Functions in the absence of oxygen, generally odorous.

2. Stabilization.--A combination of anaerobic and aerobic decomposition or anaerobic but of sufficient liquid volume to absorb most odorous products of decomposition.

3. Aerobic.--The waste material is decomposed in the presence of oxygen. This is the most odor-free type of disposal, as the nitrogen contained in the manures in the form of amino acids is converted to nitrates and nitrites and the sulfur is reduced to sulfur dioxide, which is readily soluble in water. There are, however, two times of the year, a period of approximately 1-week duration each in the fall and spring, when the temperature of the surface of the lagoon and the bottom is such that there is a shift of the bottom water to the surface and the surface water to the bottom. This is a natural phenomenon, and there is nothing that can be done about it unless artificial aeration is resorted to. This, however, is generally worth neither the effort nor the expense.

Anaerobic lagoons.--The principal reasons for the use of this type of disposal are: (a) lack of land area upon which to build a larger lagoon; or (b) a lack of sufficient water supplies to keep a larger lagoon filled.

Sometimes, however, this type is used because of the desire to use the material through sprinklers or tank vehicles. Factors to consider are: (a) What is its fertilizer value; and (b) is that value sufficient to defray the cost of pumping, hauling, and spreading?

The organic value of such material has been greatly reduced through bacterial decomposition. Characteristics of this type of lagoon are numerous, such as bubbles appearing on the liquid surface plus an occasional boiling action where bottom material churns to the surface owing to gas formation that is temporarily trapped. The gas builds up until its buoyancy overcomes the weight of the material holding it and a churning action takes place in the lagoon that is both odorous and unsightly.

Stabilization lagoons.--It has been stated[3] that 1 cu. ft. of water stabilizes 0.01 lb. manure per day. Laboratory work performed by that author has borne this out to the extent that a certain amount of aeration was introduced but no algae growth was present as the test samples were shielded from light. No odors were noted in any of the three types of manure tested--poultry, swine, and cattle.

[3] See footnote 2, page 3.

However, when the test equipment was drained and the sludge buildup measured, after a 2-month test where the above loading rate was maintained daily, the characteristic odor of poultry manure was noted emanating from the sludge; the sludge had accumulated at the rate of 1/8 inch per month. This was the highest buildup rate of the three types of manure tested.

Tests with no aeration have not been conducted but will be conducted later.

Aerobic lagoons.--Of the three types of outdoor lagoons, the aerobic is perhaps the most demanding in management unless it is excessively oversize for the amount of manure being disposed of in it.

In order to function as it should, chlorella algae (algae containing chlorophyl--thus able to carry on photosynthesis) must be present or artificial aeration must be resorted to. The algae cost nothing and, in a suitable environment, can supply adequate quantities of oxygen.

One fact that is generally overlooked is that during the hours of darkness the algae no longer produce oxygen but start consuming it. Thus, while a lagoon may be adequate and odor free during the day it can become septic, or anaerobic, during the hours of darkness. Therefore, the lagoon must be of sufficient size so that oxygen can be stored in solution during the day in order to take care of the demand at night when only surface absorption contributed to the oxygen supply.

Since surface absorption of oxygen is very important at night, it is almost imperative that the surface of the lagoon be kept clear of any floating material or film-producing substances that would insulate the surface from contact with the atmosphere.

There are times when floating masses of other types of algae may form on the lagoon surface. Generally these floating masses accumulate at the down wind side of the lagoon and can be removed comparatively easy by beating the masses. This causes them to break up and sink. In larger lagoons (an acre or more in size) running an outboard motorboat through these floating masses will break them up. This system is used by a number of municipal sewage disposal lagoons.

It is highly undesirable to use chemicals to remove these floating masses because they also affect the chlorella algae adversely; thereby, the oxygen-generating ability of the lagoon is lowered. Incidentally, copper sulfate is the chemical used to keep swimming pools algae-free. It is also used by fish hatcheries for reducing the algae population.

Other considerations involved in the construction and management of aerobic lagoons are:

- Lagoons are rich in nutrients; as a result weed growth around the edges will be rank. This is not only unsightly but provides protection for mosquito larvae. Therefore, the slope of the banks above the waterline should be such that a mower can be used to keep the banks weed free. The banks below the waterline should be as vertical as soil conditions permit. The deeper the water at the water's edge the less chance there is for bottom weed growth. In a true aerobic lagoon, minnows can be introduced; this helps to reduce the mosquito population.
- Provisions must be made in areas where rainfall is abundant to provide diversion ditches in order to prevent flooding of the lagoon and the possible contamination of local water supplies, both well and surface water.

Series versus parallel and intermittent loading of lagoons.--Material has been published[4] showing that intermittent loading and drying of septic drainage fields in clay soils generally will improve the porosity of those soils. The same findings would apply to lagoons.

Therefore, unless water is plentiful and the lagoons are anaerobic, it is suggested that when two or more lagoons seem desirable they be connected in series. This would provide primary, secondary, tertiary, etc., treatment, which produces a purer effluent and thereby reduces the chance of pollution of stream or well water.

Laboratory Work

Laboratory work on poultry manures has been done in three areas:

1. The sealing effect of manure on lagoon soils. Work has been concentrated on Manor soil so far. This soil has varying amounts of clay mixed with it. Eventually it is hoped to work with other types.
2. Rate of sludge buildup under controlled conditions.
3. BOD (biochemical oxygen demand) determinations.

Soil sealing.--Laboratory experiments to date (1964) have shown that poultry manure is one of the slowest of the various manures tested in sealing the soil of a lagoon against percolation. This may possibly be caused by the flocculating effect of the high calcium content of the manure, which may tend to keep the submerged soil surface free from the sealing tendencies of the manure. The time element is so far in excess of that for animal manures that some explanation would seem necessary.

The following tabulation shows this relationship in Manor soil formation--Howard County, Md.:

Manure tested:	Sealing time
Swine	19 days
Cow (on silage only)	39 days
Poultry	59 days

These results were obtained at the uniform loading rate of 0.01 lb. (dry weight) of manure per day per cubic foot of water under aerobic conditions but without the presence of algae, which would have contributed to the sealing of the soil because of their gelatinous nature.

Sludge buildup.--Poultry manure exhibited the greatest sludge buildup of the three types of manure tested:

Cow (on silage only)	trace only
Swine (on standard rations)	1 mm. per month
Poultry (on standard rations)	1/8 inch per month

[4] Biological Aspects of Failure of Septic Tank Percolation Systems. Univ. Calif. Col. Engin. and School of Public Health, Berkeley, Calif., August 31, 1960.

Upon completion of the soil seal, the test vehicle was drained and further notes were made on the physical properties of the residue, or sludge as follows:

- Cow and swine tests showed no odor whatsoever.
- Poultry manure exhibited the characteristic odor of decomposing poultry manure after 59 days of inundations and aeration.

BOD determination.--BOD determinations were made on manure from both mature and growing chickens that probably included varying amounts of spilled feed. Samples were mixed, weighed, and dried to a constant weight at a low temperature (115° F.). BOD was read in mg. 0_2/mg. sample (milligrams of oxygen per milligram of sample), with the following results:

Source of manure	Percent moisture fresh sample	BOD (5-day) mg.0_2/mg. sample
Mature hen	79.0	0.891
Do	78.4	.799
Do	79.2	.811
6-week broiler.	79.6	.766
Do	81.7	.801

Composting

In some areas, generally very selective, owners of smaller flocks of poultry have had some success in disposing of manure that has been composted.

In composting, the manure is generally spread in narrow bands, or windrows, on top of the ground in depths ranging from 1 to 2 feet. There it is allowed to decompose exposed to the air. Periodically the manure is turned over in order to expose the bottom layer to the air and to prevent too high a heat of decomposition. Too high a heat would tend to destroy the humus value of the composted manure.

The composting process does three things: (a) It reduces the complex and generally unstable organic compounds to a simpler, more stable form; (b) it destroys odor-causing conditions; and (c) it fixes those plant nutrients that have survived the composting process. The foregoing produces a stable and almost odorless product of varying fertilizer value.

The disadvantages of composting poultry manure are:

- Physical handling of the manure from poultry house to windrows, is required.
- Labor and equipment are needed to turn the material periodically.
- Unless protection from the weather is provided (additional capital investment), a large amount of the plant nutrients will be leached away and the composting process slowed.
- Physical handling to bulk storage for ultimate sacking (more capital investment) or bulk delivery to the customer is necessary.
- A nonuniform product in plant nutrient content due to poor management in the composting process. If the material is not thoroughly turned or mixed during composting, hot spots will develop that will drive off some of the ammonia nitrogen before it can be converted to a more stable form, i.e., nitrate nitrogen.

Success in disposing of composted manure has generally been achieved by those with relatively small flocks where there is either a local acceptance of and demand for the product or a local greenhouse desires that particular type of material for vegetable or flower forcing.

Composting, where the product is acceptable, can be a means of disposal that, while not necessarily profitable, might be a less expensive method.

Disposal of Manure Through Municipal Sewage Plants

Perhaps the greatest problem in disposal is encountered by the producer who is surrounded by urban or commercial development or both. In this case processing of any kind is generally out of the question because of the production of odors or the lack of land or both (cost of any available land would be prohibitive).

This leaves two alternatives: (a) distant hauling that is costly and odorous, or (b) disposal through the municipal sewer system. The latter method can be very efficient if certain common-sense rules and precautions are followed:

- Any poultry manure that is ultimately to be discharged into a municipal sewerage system must be pretreated so as to reduce the BOD (biochemical oxygen demand) prior to introduction into the system, to a level where the additional oxygen demand will not overload the system.
- The local Public Health authorities must be contacted before adopting this method as they must be assured that no public health hazard will be introduced and that no overload will occur in the system.
- A holding tank large enough to contain all manure and wash water for at least 30 days must be installed between the poultry house and the discharge into the sewer system. The holding tank should be in two sections, one for primary treatment and one for secondary treatment of the effluent from the primary tank. This method should provide a discharge into the municipal system of an effluent that will put a very small additional load on the sewage plant.

Pretreatment.--In a publication such as this no hard and fast rules on pretreatment can be laid down because of the number of variables involved. These include:

- Temperature both in the holding tank and in the poultry house. The higher the temperature the faster the manure will decompose and therefore the less time the material will need to be retained prior to discharge into the municipal system.
- Frequency of collecting droppings and flushing into the holding pit. The longer the interval between collecting and treatment the more decomposition will take place in the atmosphere and the greater the nitrogen loss. This nitrogen loss may have an adverse effect on the decomposition rate in the holding pit, particularly if air is forced into the holding pit to simulate an aerobic environment.
- Volume of material handled and frequency of handling. The more frequently this material is moved the smaller the pretreatment tanks need to be and the more uniform in BOD the effluent into the sewerage system is apt to be.

These variables determine the desirable size of primary and secondary pretreatment tanks and are beyond the province of this publication.

Finally, if the municipal sewerage system is to be used, the entire operation falls under the jurisdiction of the local Public Health authorities. Therefore, it is best that complete plans be made under their supervision in order to assure the best pretreatment possible of the manure prior to discharge into the municipal sewerage system. This is not only a necessity but is also good public relations.

DISPOSAL OF POULTRY WASTE OTHER THAN MANURE

There are several methods for the disposal of dead birds:

1. Burial.--This is time consuming and costly, and there is no guarantee of disease control.

2. Incineration.--This is costly in operation and capital investment and requires close supervision. Unless the incineration is properly done, disease organisms are not 100 percent controlled.

3. Specially designed septic tanks.--This disposal method is generally effective if proper temperatures are maintained. During the summer months this is no problem. During the winter months septic tanks must be heated in order to be effective. Disease control is debatable.

4. Grinder and pressure cooker.--As an alternative to the septic tank method, it is suggested that thought be given to the disposal of dead birds by this method. The advantages of this method are:

- Complete reduction of the bird to a semiliquid state with no nutrient loss but rather greater availability and digestibility of existing nutrients.
- At the elevated temperatures in pressure cookers, disease control is more positive.
- In congested areas there are generally hog feeders who regularly collect garbage from restaurants, hotels, and similar places. These hog feeders pay good prices for high-protein feed. Furthermore, these garbage feeders are required by law to cook garbage before feeding it to hogs. Material going through a pressure cooker needs no further cooking.
- While not advocated as a moneymaking method of disposal, the likelihood of defraying at least a part of the cost of disposal is probably greater than by any other method.

The disadvantages of this method are minimal:

- Locating a garbage feeder. The local county agent should be able to put the producer in contact with several.
- A chest-type deep freeze should be available to store dead birds until a sufficient number are on hand to fill the cooker.
- A heavy duty grinder is needed in order to reduce the birds to a homogeneous mass so that a uniform treatment can be achieved.
- A steam source and pressure cooker must be purchased if not available. These are generally available at secondhand equipment dealers at reasonable prices (there is not much demand for such equipment).

The pressure cooker disposal method is suggested only for the producer; packers and processors have their own methods for the disposal of poultry wastes that help to defray processing costs.

CONCLUSIONS

A study of the several methods of disposal has shown that any one method may be satisfactory under certain conditions but that no one method will be satisfactory for all conditions. The foregoing has been an effort to acquaint the producer with the various disposal methods that have had at least limited success. The advantages and disadvantages of each are given,

so that he may make an intelligent decision as to which method would be best for his particular situation. There is no "one best." Each producer must make his own decision as to what is best for him.

BIBLIOGRAPHY

(1) Anonymous.
1961. Compost - at the rate of 40 tons a week. Farmers Weekly, Mar. 10, 1961.

(2) _____
n. d. Poultry manure, value, sales, application. Tex. Agr. Col. Ext. Misc. Pub. 516.

(3) Curley, R. G., and Fairbank, W. C.
1963. Poultry manure management. Calif. Univ. Agr. Ext. Serv. Pub. AXT-95, 8 pp.

(4) Dobie, J. B.
1954. Planning a liquid manure system. Calif. Univ. Agr. Ext. Serv. Leaflet 39, 12 pp.

(5) Eby, H. J.
1963. Manure disposal lagoons. U.S. Agr. Res. Serv. ARS 42-75, 12 pp.

(6) Gilling, Tom.
1961. Liquid manure disposal and organic irrigation. Implement and Tractor, Aug. 1, 1961.

(7) Henley, Don.
1962. Livestock feeders, poultrymen profit by selling fertilizer. Doanes, Nov. 1962, pp. 14-19.

(8) United States Agricultural Marketing Service.
1959. Irrigation as a low cost sewage disposal for the poultry processor. U.S. Dept. Agr., Market. Res. Rpt. 306.

UNITED STATES DEPARTMENT OF AGRICULTURE
AGRICULTURAL RESEARCH SERVICE
BELTSVILLE, MARYLAND 20705

Official Business

Postage and Fees Paid
U.S. Department of Agriculture